external; but this does not justify the analysis of their results into two parts.

Nor does the matter become plainer to me when I follow Mr. Poulton in his application of his definition to concrete cases. The first is the case of the so-called "Exercierknochen," a reaction on an external force resulting in a certain number of changes of tissue. How is it possible to classify those changes into two categories—the one including changes directly due to the external force, the other changes not directly due to it? If the stress is to be laid on the word "direct," then one must respectfully ask what is its meaning? how is it to be ascertained and verified? one must inquire whether what is said to be an indirect result, means anything but a result which is transmitted? in which case we should find ourselves in a vicious circle. I will not follow Mr. Poulton through the other instances, but I believe the reader will find, like me, that each raises similar difficulties, and that in no case does he analyse the actual result into two distinct and separable parts.

Mr. Galton proposes, and Prof. Ray Lankester adopts another definition, viz. "Characters are said to be acquired when they are regularly found in those individuals only who have been subjected to certain special and abnormal conditions." Now I suppose that characters can be found regularly only either (1) in individuals exposed to conditions which induce them, or (2) in individuals who have inherited them. To say, then, of a character that it appears only regularly in individuals exposed to certain conditions, is to say that it does not appear in individuals by inheritance, and the proposition that acquired characters are not transmissible is thus reduced to an identical one. The possibility of inheritance is excluded by the definition, and the inquiry whether acquired characters are inherited is impossible.

I do not propose to follow your learned correspondents into many of the subjects touched on by them; but the more their letters are read, the more apparent does it become that they are not at one, either with themselves or with Lamarck or Weismann, as to the use of the words "acquired characters;" and for myself, I repeat my regret that an inquiry of great moment should be obscured, as I venture to think, by a premature use of classificatory words before the real classification of nature herself has been ascertained. For the question, "Are acquired characters transmissible?" I hope to see substituted the inquiry "What characters are transmitted?" EDW. FRY.

The alleged Absoluteness of Motions of Rotation.

All motion is relative. This apparently universal statement is a particular statement about the meanings of words. The word "motion" means "relative motion," or, more precisely, "the motion of a body" means its motion relative to other bodies. We may go further and make the still more fundamental statement that *all position is relative*, or, in other words, the position of a body means its position relative to other bodies. It is easy for anyone who puts words together without reflecting sufficiently on their meaning to put together the noun "motion" or "position" and the adjective "absolute," but the expressions "absolute motion" and "absolute position" are nevertheless meaningless, just as much so as "white blackness," "retrograde progress," "the action between a rough body and a smooth body at their point of contact," or "the potential energy of non-conservative forces."

The above remarks contain the standpoint from which it is concluded that motions of rotation are no more "absolute" than motions of translation. Anyone who accepts them for translation, but rejects them for rotation, places himself in an illogical position. Unless I have misunderstood them, this is the position occupied by Maxwell and Prof. Greenhill. The standpoint of those who assert that position and motion are in all cases relative is directly opposed to that of Newton. He held that there is absolute position in immovable space, and relative position with respect to bodies, and correspondingly there are absolute and relative motions; that absolute motion of a body is its transference from one absolute place to another absolute place; that we can never determine the absolute place of a body, but only its relative place; that in cases of rotation we can distinguish absolute from relative motion by the effects of "centrifugal force." He gives no indication how to distinguish absolute and relative motions of translation. From the impossibility of determining the absolute position of a body it seems to follow that absolute motion of translation cannot be determined; this view is adopted by Maxwell.

Assuming that it is the object of the Science of Mechanics to give as simple a description as possible of the observed facts about the motions of bodies, the assumption at the outset of absolute motions or positions about which we can know nothing appears an unnecessary complication.

From a logical point of view the cardinal statement in the discussion is that all position is relative. It appears to be conceded by Newton, and has been insisted upon by Maxwell, that all knowable position is relative. To say that at any instant a body has an absolute position in space, but that we can never know where it is except by reference to other bodies, that is to say that every body has an absolute position, although we can only know its relative position, is to introduce an unnecessary complication, if it is not to talk nonsense.

What is done in practice is to determine the position of a point by reference to a Cartesian system of axes, or by an equivalent method. What is called "the velocity of a body" is its velocity relative to the axes; what is called "the acceleration of a body" is its acceleration relative to the axes; a body has a motion of rotation when the angles between lines of the body and any axis are changing with the time. It is part of the solution of a mechanical problem, as presented by any set of observed facts, to determine the system of axes with reference to which the description of the observed motion becomes as simple as possible, and there exists a calculus for transforming the expression of a motion from one system of axes to another when the relative motion of the two systems is known.

The question how the axes are to be determined has been much discussed, but no general answer appears possible. Particular answers apply in particular cases. In general any three points, not in a straight line, determine a set of coordinate axes. For one of the points may be chosen as origin, the line joining this point to another of the points may be chosen as one coordinate axis, and the plane of the three points may be chosen as one coordinate plane. For the three points any identifiable parts of bodies may be taken; but, in general, axes so chosen will be inconvenient, or, what comes to the same thing, the description of a motion by reference to them will not be simple.

The description of motion is generally made in terms of the concept *force*, that is to say, we state the acceleration relative to the axes which a free body placed in a given position relative to the axes, and moving with a given velocity relative to the axes would have, and the nature of the constraints which give rise to differences of acceleration in a constrained and a free body moving through the same position with the same velocity relative to the axes. In an actual problem the acceleration of a free body whose other circumstances (position and velocity relative to the axes) are known, must be found by experiment. It does not concern the matter now under discussion that among these circumstances position is generally predominant over velocity in determining accelerations. What is of more importance is the fact that *the force acting on a body depends on the system of axes chosen.* For the force is a vector quantity whose line of action coincides with the line of the acceleration relative to the axes, and whose magnitude is proportional to this acceleration. This point has been noted by Maxwell. The result that the field of force depends partly on the axes is frequently a guide to the choice of convenient axes of reference, namely, we choose axes with respect to which the expression of the field of force is simple, and it often happens that in this way all motional forces, other than frictional resistances, can be made to disappear. An easy and striking example of the differences introduced by changing the axes can be found by considering the motion of two particles which move in one of the planes chosen as coordinate planes with uniform velocities in different lines relative to the coordinate axes. If a new set of axes is constructed by taking one of the particles as origin, and the line joining the particles as one axis, the acceleration of the other particle relative to the new axes is directed towards the first particle, and varies inversely as the cube of the distance between the two particles. Another very interesting example is furnished by Foucault's pendulum, to be discussed presently.

These remarks will serve as a preparation for the way in which we interpret, in accordance with the principle of the relativity of motion, those experiences which have been held to favour the view that motions of rotation admit of absolute determination. The history of the discussion appears to show that little would have been heard of this doctrine apart from the desire to explain to a public unused to regard motion as relative the theory of the rotation of the earth. To one who has mastered

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the relativity of motion it is manifestly the same thing to say (1) that referred to axes fixed in the earth all the stars describe circles every day about the polar axis, or (2) that referred to axes fixed among the stars the earth rotates about its polar axis once a day. If any ground can be alleged for holding that one of these statements is the simpler, that is a ground for a certain choice of axes, not for saying that one motion is "real" or "absolute," and the other "relative" or "apparent."

All the so-called "proofs of the earth's rotation" are deductions from particular experiences which show that other motions besides the diurnal relative motions of the earth and stars are more simply expressed by referring to axes fixed among the stars than by referring to axes fixed in the earth. They all depend on the specification of "the acceleration due to gravity" near the earth's surface. The neighbourhood of the earth is a field of force, and the magnitude and direction of the force at any point depend on the axes of reference. The specification of the field of force is simplest when referred to the centre of the earth as origin, and to axes fixed in direction with reference to the stars. The field is then expressed by the law of gravitation.

It is worth while to elucidate this matter in greater detail by an examination of the most famous of these "proofs," that by means of Foucault's pendulum. What is observed is that if the pendulum is really free to swing about a point, and if the bob always passes above the same point of a horizontal table (fixed with reference to the earth) when at the lowest point of its swing, then the plane of vibration turns slowly round, so that the line of vibration is above now one, now another line drawn on the table, the oscillation in the line being practically simple harmonic. If this motion were referred to axes fixed with reference to the table, there would be a component acceleration from the bob of the pendulum towards the point of support (to be accounted for by the constraint), a component acceleration in the plane of vibration at right angles to the former (which we should recognise as a component of gravity), and a component acceleration perpendicular to the plane of vibration, and proportional at any instant to the velocity in the simple harmonic motion. If we had nothing else to guide us, no observation of the stars, no theory of gravitation, but knew only from less refined observations that free bodies fall downwards with constant acceleration, we should have to do two things: we should have to try to simplify the specification of the acceleration of the bob of the pendulum by referring to a new set of axes, and we should have to conclude that our previous observations of falling bodies had not disclosed all the facts about the field of force in the neighbourhood of the earth. We should simplify the specification of the observed accelerations by referring to axes which (relative to the earth) rotate with the plane of vibration of the pendulum, and we should conclude that such axes are required in order that the laws governing the motion of falling bodies may be correctly formulated. What the experiment with Foucault's pendulum really proves is not that the rotation of the earth relative to the stars is an "absolute motion," but that the system of axes, with reference to which the acceleration of a free body near the earth's surface is of constant amount and directed towards the earth's centre, is not fixed in the earth, but (relative to axes fixed in the earth) these axes rotate with the stars.

It will be found on examination that every other so-called "proof of the earth's rotation" is of the same character. By each it is shown that the earth rotates in the same time and in the same way relative to the axes required for the statement of the law of gravitation as relative to the stars. It is not legitimate to suppose that two relatives make one absolute.

It is true that the conclusion at which we have arrived takes longer to state, and appears at first sight less simple than the statement by way of "absolute motion," but it contains no undefined terms, and no reference to anything assumed to exist, but about which nothing can be known.

Objection has been taken to the attempt to express mechanical theory in terms of relative motion, on the ground that it will be perplexing to beginners, and difficult at any stage. In answer to this it may be urged that in teaching beginners there is no need to say anything about either relativity or absoluteness. The motions that interest them are motions relative to the earth; the motions of boats, trains, cricket-balls, billiard-balls, and machinery; things that can be sufficiently described by reference to lines fixed in the earth. It is only at a later stage when general mechanical theories have to be studied, and a foundation laid for physical astronomy and mathematical physics, that is proper to insist on the relativity of motion; and at this stage it appears to me more important that our statements of principles should be free from metaphysical obscurity than that they should be verbally short.

A. E. H. LOVE.

The Antiquity of the "Finger-Print" Method.

SIR WILLIAM HERSCHEL, in his letter to NATURE (Nov. 22, p. 77), expresses his unbelief in the statement in the *Nineteenth Century* (No. 211, p. 365), which ascribes to the Chinese the original invention of the "finger-print" method of personal identification. While I do not know upon what Mr. Spearman has founded this statement, I have collected from a few sources some facts which seem to justify the claim made on behalf of the Chinese.

Although at present I have no record to refer to, it is a fact that every Japanese, old enough to have outlived the *ancien régime* that passed away in 1869, well remembers the then current usage of "stamping with the thumb" (*Bo-in*) on legal papers, popularly called "nail-stamp" (*Tsume-in*), on account of the common use of a thumb with the edge of its nail in ink; whereas on papers of solemn contract, accompanied by written oath, the "blood-stamp" (*Keppan*), or the stamp of the ring-finger in blood drawn therefrom, was demanded.[1]

Chûryô Katsurakawa, the Japanese antiquary (1754–1808), writes on the subject as follows: "According to the 'Domestic Law ') (*Korei*), to divorce the wife the husband must give her a document stating which of the Seven Reasons[2] was assigned for the action. . . . All [letters] must be in the husband's handwriting, but in case he does not understand how to write, he should sign with a finger-print. An ancient commentary on this passage is: 'In case a husband cannot write, let him hire another man to write the document . . . and after the husband's name sigh with his own index-finger.' Perhaps this is the first mention [in Japanese literature] of the 'finger-print' method" (1) This "Domestic Law" forms a part of the "Laws of Taihô" enacted in 702 A.D.; with some exceptions, the main points of these "Laws" were borrowed and transplanted from the Chinese "Laws of Yung-Hwui" (*circa* 650–55 A.D.) (2); so it appears that the Chinese of the 7th century A.D. had already acquired the "finger-print" method.

After the above-quoted passage, Katsurakawa continues thus: "That the Chinese apply on divorce-papers the stamps of the ends of the thumb and four fingers, which they call 'Shau-mú-ying' (*i.e.* hand-pattern stamp) is mentioned in 'Shwui-hü-chuèn,' &c." (3). This "Shwui-hü-chuèn" is one of the most popular novels enjoyed by the modern Chinese—so popular that I have met with many Chinese labourers possessing it in the West Indies; its heroes flourished about 1160, and its author lived in the twelfth or thirteenth century A.D. (4). As is usual with many other examples, this novel gives us more accurate descriptions of minor institutional features that co-existed with either the heroes or the author, or both (5). After making careful search in this novel, I can now affirm that the Chinese in the twelfth or thirteenth century used the finger-prints, not only in divorce, but also in criminal cases. Thus the chapter narrating Lin Chung's divorce of his wife, has this passage: "Then Lin Chung, after his amanuensis had copied what he dictated, marked his sign-character, and stamped his 'hand-pattern'" (6). And in another place, giving details of Wu Sung's capture of the two women, the murderers of his brother, we read: "He called forth the two women; compelled them both to ink and stamp their fingers; then called forth the neighbours; made them write down the names and stamp [with fingers]" (7).

It has been lately suggested by my friend, Mr. Teitarô Nakamura, that possibly the "finger-stamp" was merely a simplified form of the "hand-stamp," which latter method had once been so current in Japan that it gave to the documents the common names "Tegata" (*i.e.* hand-pattern) and "Oshite" (*i.e.* impressed hand)[3] (8). This view applies equally well to

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[1] The "thumb-stamp" was equally regarded with the formal engraved seal (*Jitsu-in*), but the "blood-stamp" had nothing to do for identification. For the formula of the latter mode of stamp, *vide* Ota, "Ichiwa Ichigen," new edition, Tokyo, 1882, vol. xiii. p. 39.

[2] The Seven Reasons for divorcing the wife are: (1) filial disobedience; (2) barrenness; (3) licentiousness; (4) jealousy; (5) leprosy; (6) loquacity; (7) larceny.

[3] It must not be presumed as a fact that after the "finger-stamp" was introduced, it soon supplanted the "hand-stamp"; for even in the seventeenth century the latter was sometimes used, as is instanced in the writing of Katô-Kiyomasa (1562–1611) preserved in a monastery near Tokyo. *Cf.* Kitamura, "Kiyû Shôran," new edition, 1882, vol. iv. p. 16.

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